

# EXHIBIT 2

US006523113B1

(12) **United States Patent**  
**Wehrenberg**

(10) **Patent No.:** **US 6,523,113 B1**  
(45) **Date of Patent:** **Feb. 18, 2003**

(54) **METHOD AND APPARATUS FOR COPY PROTECTION**

5,905,800 A \* 5/1999 Moskowitz et al. .... 380/28  
6,131,161 A \* 10/2000 Linnartz ..... 713/176  
6,141,753 A \* 10/2000 Zhao et al. .... 713/176

(75) Inventor: **Paul J. Wehrenberg**, Palo Alto, CA (US)

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(73) Assignee: **Apple Computer, Inc.**, Cupertino, CA (US)

"Interim Report: Results of Phases I and II", Data Hiding SubGroup Copy Protection Technical Working Group, Version 1.0, May 26, 1998.

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **09/188,917**

*Primary Examiner*—Gilberto Barrón

*Assistant Examiner*—Paul E. Callahan

(22) Filed: **Nov. 9, 1998**

(74) *Attorney, Agent, or Firm*—Beyer Weaver & Thomas, LLP

**Related U.S. Application Data**

(60) Provisional application No. 60/088,654, filed on Jun. 9, 1998.

(51) **Int. Cl.**<sup>7</sup> ..... **H04L 9/00; H04L 9/30**

(52) **U.S. Cl.** ..... **713/176; 380/201; 380/203; 380/210; 380/30**

(58) **Field of Search** ..... **380/201, 203, 380/210; 713/176**

**ABSTRACT**

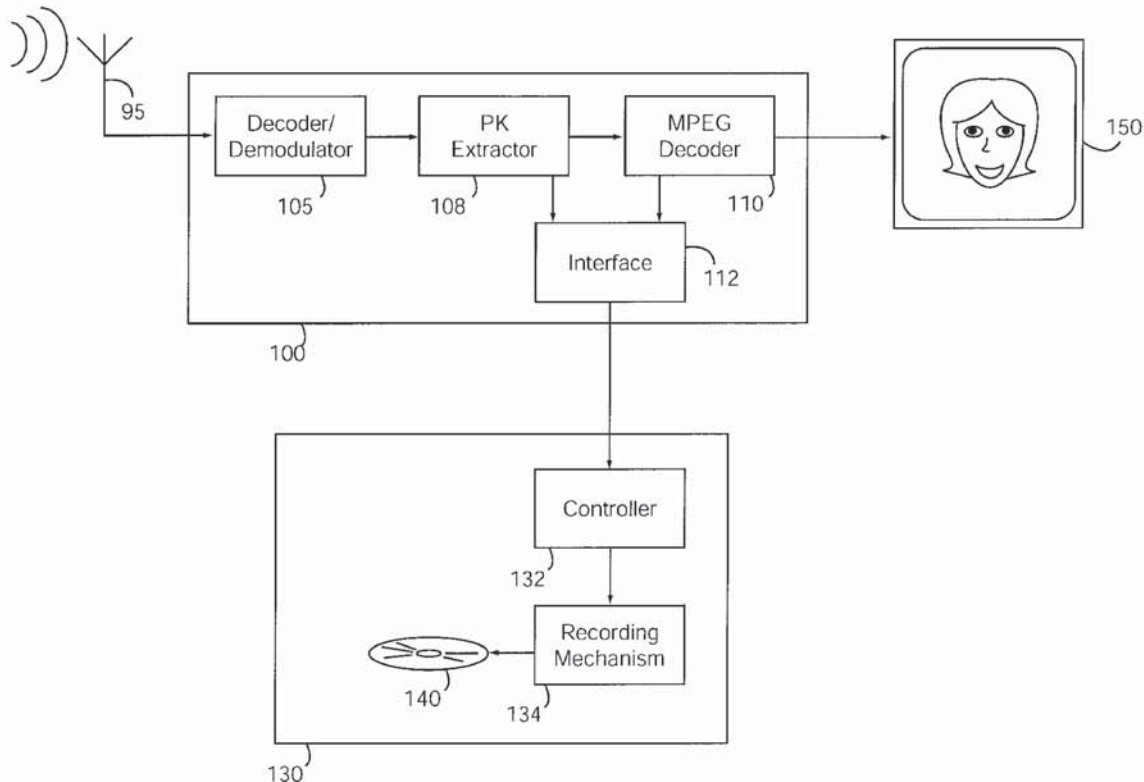
Copy protection techniques that utilize a watermark and a permission key are disclosed. The copy protection techniques can provide single-copy copy protection in addition to different levels of copy protection. The permission key and the watermark can also permit the invention to yield variable levels of copy protection. In one embodiment, content including a watermark is transmitted to a recipient. The recipient is allowed to read the content but not record the content unless the recipient possesses a permission key.

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5,613,004 A \* 3/1997 Cooperman et al. .... 380/28

**18 Claims, 10 Drawing Sheets**



US006457058B1

(12) **United States Patent**  
**Ullum et al.**(10) **Patent No.:** **US 6,457,058 B1**  
(45) **Date of Patent:** **Sep. 24, 2002**(54) **NETWORK SWITCH WITH HASH TABLE LOOK UP**(75) Inventors: **Daniel Ullum**, San Jose; **Thomas J. Edsall**, Mountain View; **Soei-Shin Hang**, Sunnyvale, all of CA (US)(73) Assignee: **Cisco Technology, Inc.**, San Jose, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/904,431**(22) Filed: **Jul. 12, 2001****Related U.S. Application Data**

(63) Continuation of application No. 09/162,730, filed on Sep. 29, 1998, now Pat. No. 6,266,705.

(51) Int. Cl.<sup>7</sup> ..... **G06F 15/173**(52) U.S. Cl. .... **709/238; 709/245**

(58) Field of Search ..... 709/238, 245, 709/236; 711/216, 206, 208, 209, 205; 370/259, 401, 409, 392, 428, 474, 423, 360, 380, 381

(56) **References Cited****U.S. PATENT DOCUMENTS**

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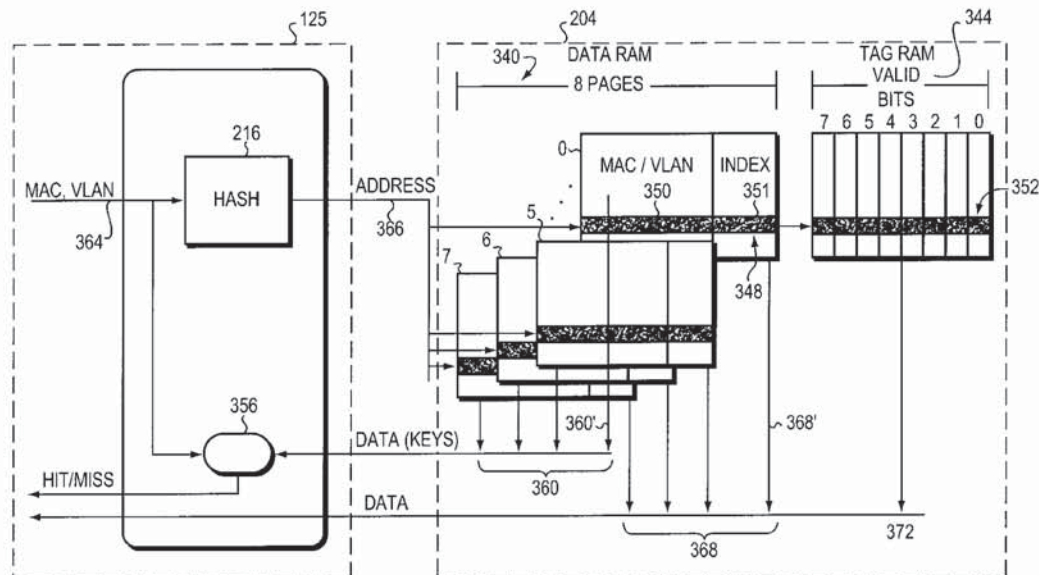
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Primary Examiner—Mehmet B. Geckil

(74) Attorney, Agent, or Firm—Cesari and McKenna, LLP

(57) **ABSTRACT**

An improved look up mechanism for accessing a RAM to obtain forwarding information for data frames being transported among ports of a high-performance switch is provided. The look up mechanism includes a multi-page look up table and associated hashing technique. A media access control (MAC) address and a virtual local area network (VLAN) identifier are transformed with a hash function to obtain a hash key. The hash key is an address pointing to a particular entry in the look up table. A virtual first page is also derived from the hash key, which selects a particular physical page of the look up table to be initially accessed each time that MAC address/VLAN pair is used. The look up mechanism may also be used to access a short cut table containing Layer 3 short cut information. In either case, ultimately, the likelihood is increased that a match will be found on the first RAM access, thus maintaining high-speed switch performance.

**23 Claims, 5 Drawing Sheets**



US006978370B1

(12) **United States Patent**  
**Kocher**(10) **Patent No.:** **US 6,978,370 B1**  
(45) **Date of Patent:** **Dec. 20, 2005**(54) **METHOD AND SYSTEM FOR  
COPY-PREVENTION OF DIGITAL  
COPYRIGHT WORKS**5,822,436 A \* 10/1998 Rhoads ..... 380/54  
5,862,218 A \* 1/1999 Steinberg ..... 713/176**FOREIGN PATENT DOCUMENTS**(75) Inventor: **Paul C. Kocher**, San Francisco, CA  
(US)

EP 0717337 A1 \* 6/1994 ..... G06F 12/14

**OTHER PUBLICATIONS**(73) Assignee: **Cryptography Research, Inc.**, San  
Francisco, CA (US)Gustavus Simmons Contemporary Cryptology, IEEE Press  
1991.\*(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.Lecture Notes in Computer Science, Ross Anderson (Ed.),  
"Information Hiding," First International Workshop,  
Cambridge, U.K., May 30-Jun. 1, 1996 Proceedings,  
Springer.

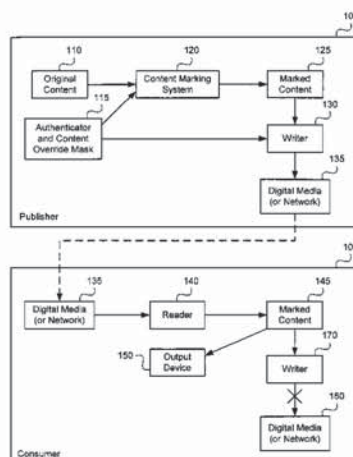
\* cited by examiner

(21) Appl. No.: **09/274,496**(22) Filed: **Mar. 23, 1999***Primary Examiner*—Kim Vu*Assistant Examiner*—Thanhnga Truong(74) *Attorney, Agent, or Firm*—Sonnenschein Nath &  
Rosenthal LLP**Related U.S. Application Data**(60) Continuation of application No. 08/882,511, filed on  
Jun. 25, 1997, now abandoned, which is a division of  
application No. 08/707,289, filed on Sep. 3, 1996,  
now abandoned.(57) **ABSTRACT**(51) **Int. Cl.**<sup>7</sup> ..... **H04L 9/00**(52) **U.S. Cl.** ..... **713/176; 380/201**(58) **Field of Search** ..... 713/193, 161,  
713/176, 168; 705/51, 57–59; 380/201

Methods and apparatus for marking digital material and for detecting marks therein. For mark detection, the material is divided into a plurality of blocks, to which a non-collision resistant compression function is applied. Compression outputs are placed in a shift register, whose value is tested for predetermined values or patterns. Mark embedding may be performed by modifying the data (for example by altering low-order bits and other non-critical regions) such that the outputs of the compression operation, when used as an input to the shift register, yield a predetermined value or pattern. A Hamming Majority operation, computed as the most common bit in a block, may be used as the compression operation, enabling marking and mark detection with material of virtually all types and formats. Mark detection technology may be implemented in media writers and other devices to determine whether the digital material is copyrighted or otherwise protected. An override capability is provided to allow authorized parties to bypass the protection.

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**10 Claims, 10 Drawing Sheets**

US005530751A

**United States Patent** [19][11] **Patent Number:** **5,530,751****Morris**[45] **Date of Patent:** **Jun. 25, 1996**[54] **EMBEDDED HIDDEN IDENTIFICATION  
CODES IN DIGITAL OBJECTS**

5,398,285 5/1995 Borgelt et al. .... 380/4

**FOREIGN PATENT DOCUMENTS**[75] **Inventor:** **Dale C. Morris**, Menlo Park, Calif.

0366381 10/1989 European Pat. Off. .

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[73] **Assignee:** **Hewlett-Packard Company**, Palo Alto,  
Calif.

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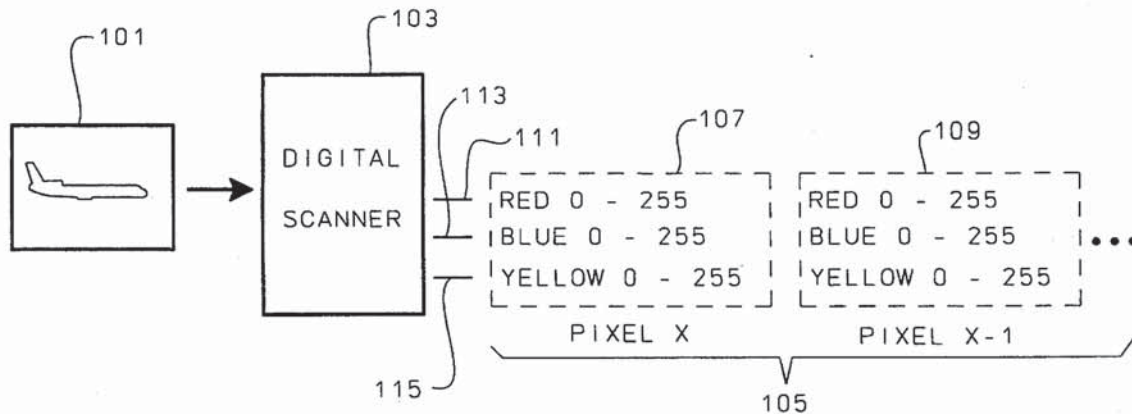
WO92/16944 1/1992 WIPO .

[21] **Appl. No.:** **269,807**[22] **Filed:** **Jun. 30, 1994***Primary Examiner*—Salvatore Cangialosi*Attorney, Agent, or Firm*—Howard R. Boyle[51] **Int. Cl.<sup>6</sup>** ..... **H04L 9/00**[57] **ABSTRACT**[52] **U.S. Cl.** ..... **380/4**[58] **Field of Search** ..... 380/4, 25

A method and apparatus for encoding identification information into a stream of digital data representing an object. The digital data representing an object is modified to add embedded identification information into the data. This modification is done such that the resultant changes to the object are not objectionable to the user. By comparing the original digital data to the modified data, the possessor of the original data can recover the embedded identification information. However the identification information is effectively unavailable to anyone not possessing the original data.

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**8 Claims, 10 Drawing Sheets**



US006823455B1

(12) **United States Patent**  
**Macy et al.**

(10) **Patent No.:** **US 6,823,455 B1**  
 (45) **Date of Patent:** **Nov. 23, 2004**

(54) **METHOD FOR ROBUST WATERMARKING OF CONTENT**

(75) Inventors: **William W. Macy**, Palo Alto, CA (US);  
**Matthew J. Holliman**, Libertyville, IL (US);  
**Minerva Ming-Yee Yeung**, Sunnyvale, CA (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/288,836**

(22) Filed: **Apr. 8, 1999**

(51) Int. Cl.<sup>7</sup> ..... **H04L 9/00; H04K 1/00; G09C 3/00; G09C 5/00**

(52) U.S. Cl. .... **713/176; 380/38; 380/54**

(58) Field of Search ..... **713/176; 380/54, 380/28**

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*Primary Examiner*—Gilberto Barrón

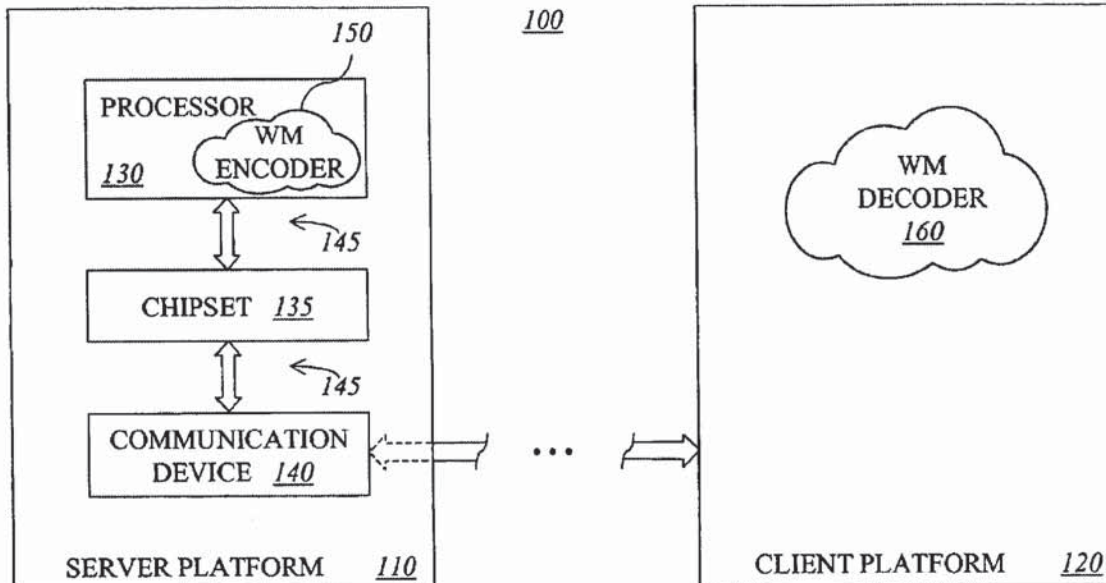
*Assistant Examiner*—Benjamin E. Lanier

(74) *Attorney, Agent, or Firm*—Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

One inventive aspect pertains to a watermarking mechanism that allows a watermark to be determined from only a part of the video sequence without human intervention and without reference to the original watermarked frames. This watermark has improved invisibility, detection reliability and robustness. Invisibility is improved through the inclusion of frame difference parameters to calculate the amplitude of the watermark. Detection reliability and robustness can be improved by assuring that opposite signed values for the pseudo-random number sequence are spatially near each other and using data blocks forming the data sets, respectively. Another inventive aspect pertains to a watermarking mechanism that is exclusively dependent on the data contained in the data sets and is completely interoperable between spatial and compressed domains.

**2 Claims, 9 Drawing Sheets**



US00668246B1

(12) **United States Patent**  
**Yeung et al.**(10) **Patent No.:** **US 6,668,246 B1**  
(45) **Date of Patent:** **Dec. 23, 2003**(54) **MULTIMEDIA DATA DELIVERY AND  
PLAYBACK SYSTEM WITH MULTI-LEVEL  
CONTENT AND PRIVACY PROTECTION**(75) Inventors: **Minerva Ming-Yee Yeung**, Sunnyvale, CA (US); **Matthew J. Holliman**, Libertyville, IL (US); **Robert G. Liu**, Sunnyvale, CA (US); **William W. Macy**, Palo Alto, CA (US); **Boon-Lock Yeo**, Sunnyvale, CA (US)(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/275,905**(22) Filed: **Mar. 24, 1999**(51) **Int. Cl.**<sup>7</sup> ..... **G06F 17/60**(52) **U.S. Cl.** ..... **705/57; 380/211; 705/1; 705/51; 713/150**(58) **Field of Search** ..... **380/200, 201, 380/211; 705/1, 50, 51, 52, 54, 57; 713/150**(56) **References Cited****U.S. PATENT DOCUMENTS**4,933,971 A \* 6/1990 Bestock et al. .... 380/44  
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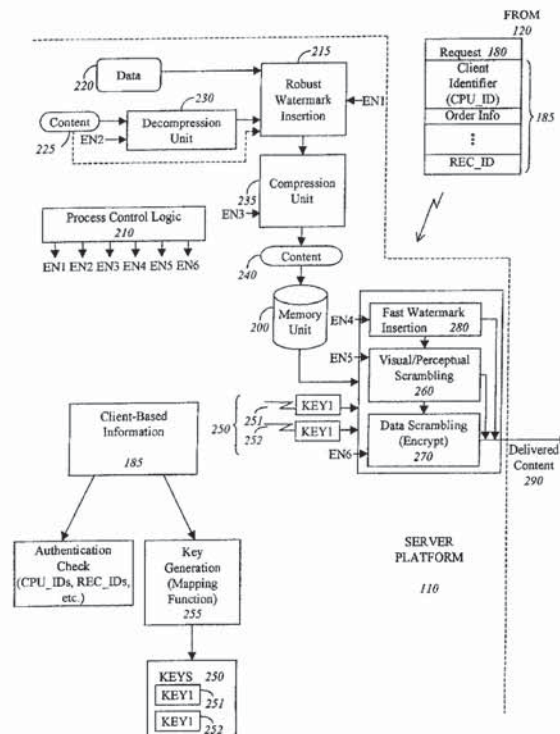
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Bobrowski: "Database in a client/server world—Understanding the unique challenges of keeping your client/server database environment secure"; DBMS, Sep. 1, 1994, vol. 7, No. 10, pp. 48–48, (Abstract Only).\*

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*Primary Examiner*—Edward R. Cosimano(74) *Attorney, Agent, or Firm*—Blakely, Sokoloff, Taylor & Zafman LLP(57) **ABSTRACT**

A content distribution system comprising a server platform and a client platform. The server platform includes a memory unit to store digital content and access control logic to activate content protection mechanisms that provide multiple levels of access protection to the digital content. In communication with the server platform, the client platform plays back segments of the digital content at one of a plurality of quality levels.

**24 Claims, 9 Drawing Sheets**



US006282650B1

(12) **United States Patent**  
**Davis**(10) **Patent No.:** **US 6,282,650 B1**  
(45) **Date of Patent:** **Aug. 28, 2001**(54) **SECURE PUBLIC DIGITAL WATERMARK**(75) Inventor: **Derek L. Davis**, Phoenix, AZ (US)(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/237,323**(22) Filed: **Jan. 25, 1999**(51) Int. Cl.<sup>7</sup> ..... **H04L 9/32; H04L 1/44; G06F 12/14**(52) U.S. Cl. .... **713/176; 713/193; 380/246; 380/282**(58) Field of Search ..... **713/172, 176, 713/193, 194; 380/46, 51, 54, 55, 243, 246, 282, 285**(56) **References Cited****U.S. PATENT DOCUMENTS**

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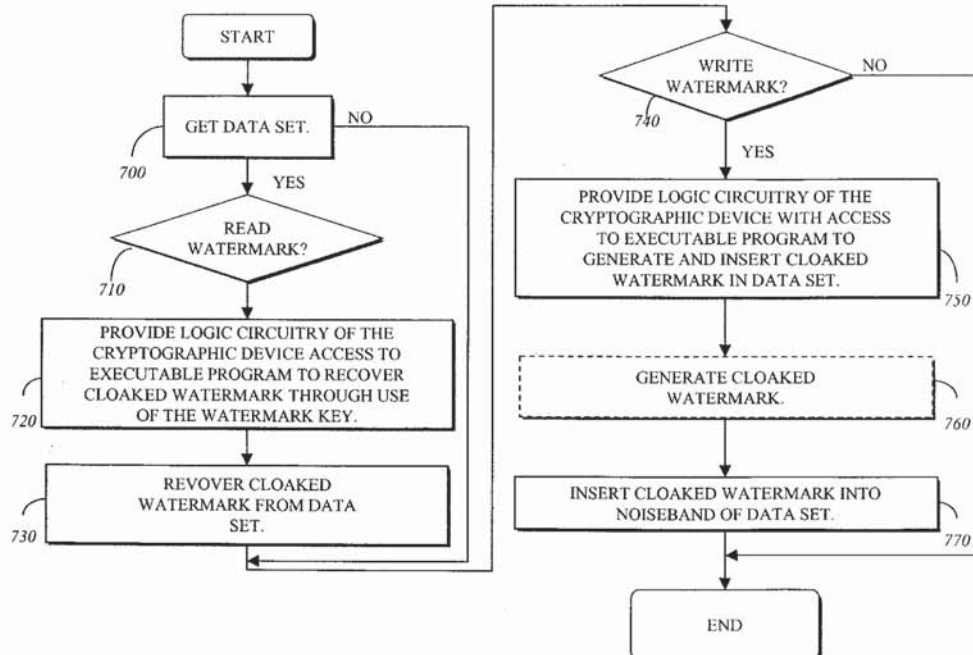
Primary Examiner—Tod Swann

Assistant Examiner—Justin T. Darrow

(74) Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor &amp; Zafman LLP

(57) **ABSTRACT**

A cryptographic device and corresponding method for producing a cloaked watermark which is a private watermark having the functionality of a public watermark. In one embodiment, the cryptographic device comprises an internal memory and a processor contained in a package. The internal memory provides a region for storage of key information used at least to produce the cloaked watermark. The processor is coupled to the internal memory and is responsible for producing a cloaked watermark based on the key and for inserting the cloaked watermark into an outgoing data set.

**20 Claims, 5 Drawing Sheets**



US005633932A

**United States Patent** [19]

Davis et al.

[11] **Patent Number:** 5,633,932[45] **Date of Patent:** May 27, 1997

[54] **APPARATUS AND METHOD FOR PREVENTING DISCLOSURE THROUGH USER-AUTHENTICATION AT A PRINTING NODE**

5,509,074 4/1996 Choudhury et al. .... 380/23

[75] Inventors: **Derek L. Davis**, Phoenix; **Lionel Smith**, Queen Creek, both of Ariz.

Primary Examiner—Bernarr E. Gregory

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor &amp; Zafman

[73] Assignee: **Intel Corporation**, Santa Clara, Calif.

[57] **ABSTRACT**

[21] Appl. No.: 574,843

[22] Filed: Dec. 19, 1995

[51] Int. Cl.<sup>6</sup> ..... H04L 9/32; H04L 9/00; B41J 29/54

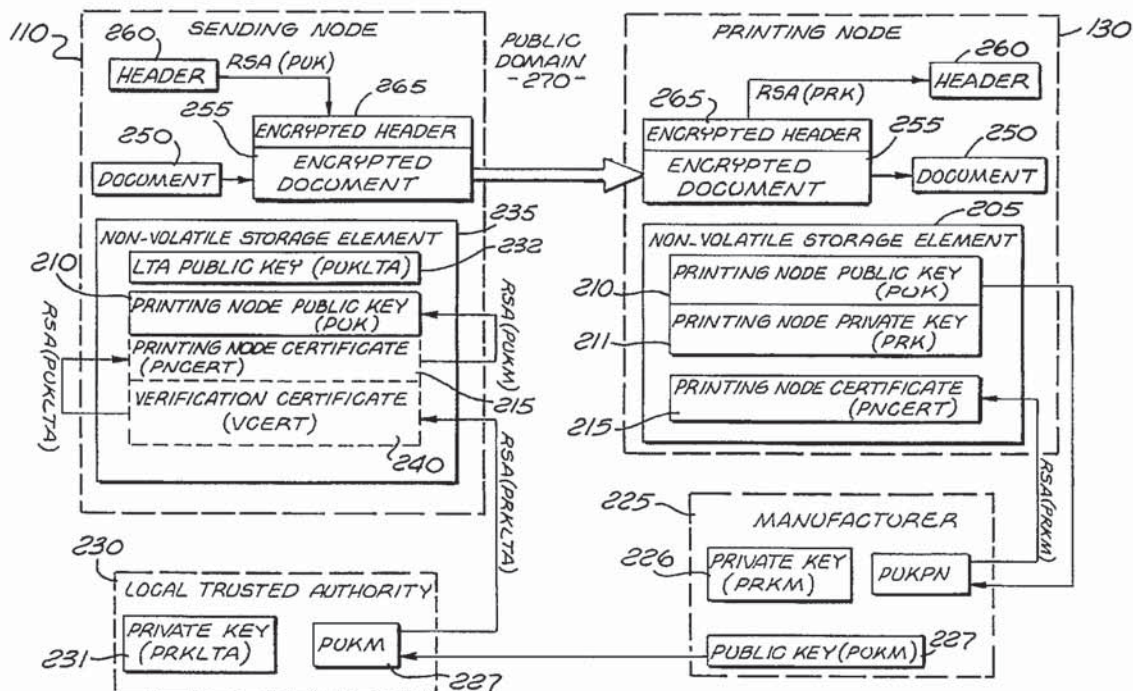
[52] U.S. Cl. .... 380/25; 380/3; 380/4; 380/23; 380/30; 380/49; 380/51; 380/55; 340/825.31; 340/825.34

[58] Field of Search ..... 380/3, 4, 23, 25, 380/30, 49, 50, 51, 55, 59; 340/825.31, 825.34

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**24 Claims, 4 Drawing Sheets**

US006785815B1

(12) **United States Patent**  
**Serret-Avila et al.**

(10) **Patent No.:** US 6,785,815 B1  
(45) **Date of Patent:** Aug. 31, 2004

- (54) METHODS AND SYSTEMS FOR ENCODING AND PROTECTING DATA USING DIGITAL SIGNATURE AND WATERMARKING TECHNIQUES

- |    |              |        |
|----|--------------|--------|
| EP | 0 903 943 A2 | 3/1999 |
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- (75) Inventors: **Xavier Serret-Avila**, Santa Clara, CA (US); **Gilles Boccon-Gibod**, Los Altos, CA (US)

Marc Schneider, et al., *A Robust Content Based Digital Signature for Image Authentication*, Proceedings of the International Conference on Image Processing, IEEE, Sep. 26, 1996, pp. 227-230.

- (73) Assignee: **InterTrust Technologies Corp.**, Santa Clara, CA (US)

(List continued on next page.)

- (\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 953 days.

*Primary Examiner*—Thomas R. Peeso

- (74) Attorney, Agent, or Firm—Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P.

- (21) Appl. No.: 09/588,652

- (57) **ABSTRACT**

- (22) Filed: **Jun. 7, 2000**

### Related U.S. Application Data

- (60) Provisional application No. 60/138,171, filed on Jun. 8, 1999.

- (51) **Int. Cl.**<sup>7</sup> ..... **G06F 1/26**

- (52) U.S. Cl. .... 713/176; 713/182; 713/200;  
713/201

- (58) **Field of Search** ..... 713/176, 182,  
713/189, 200, 201

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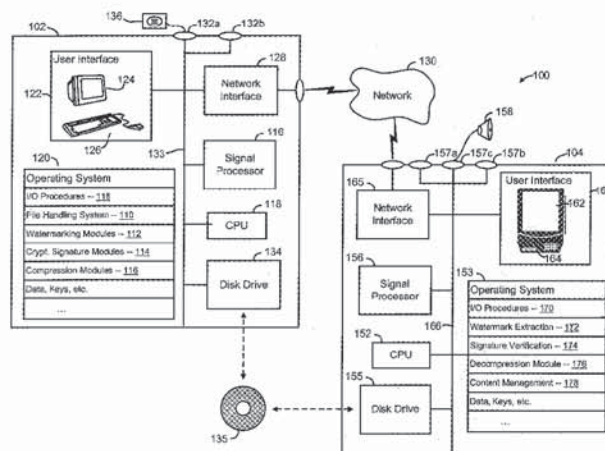
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**46 Claims, 20 Drawing Sheets**





US005943422A

**United States Patent** [19][11] **Patent Number:** **5,943,422****Van Wie et al.**[45] **Date of Patent:** **Aug. 24, 1999**

[54] **STEGANOGRAPHIC TECHNIQUES FOR SECURELY DELIVERING ELECTRONIC DIGITAL RIGHTS MANAGEMENT CONTROL INFORMATION OVER INSECURE COMMUNICATION CHANNELS**

[75] Inventors: **David M. Van Wie**, Sunnyvale; **Robert P. Weber**, Menlo Park, both of Calif.

[73] Assignee: **InterTrust Technologies Corp.**, Sunnyvale, Calif.

[21] Appl. No.: **08/689,606**

[22] Filed: **Aug. 12, 1996**

[51] Int. Cl.<sup>6</sup> ..... **H04N 7/167**

[52] U.S. Cl. .... **380/9; 380/5**

[58] Field of Search ..... 380/9, 20, 4, 5,  
380/28; 382/232

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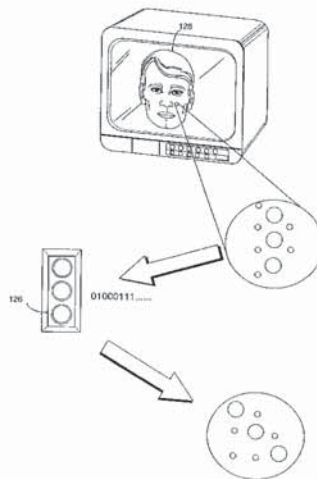
*Primary Examiner*—David Cain

*Attorney, Agent, or Firm*—Nixon & Vanderhye P.C.

[57] **ABSTRACT**

Electronic steganographic techniques can be used to encode a rights management control signal onto an information signal carried over an insecure communications channel. Steganographic techniques ensure that the digital control information is substantially invisibly and substantially indelibly carried by the information signal. These techniques can provide end-to-end rights management protection of an information signal irrespective of transformations between analog and digital. An electronic appliance can recover the control information and use it for electronic rights management to provide compatibility with a Virtual Distribution Environment. In one example, the system encodes low data rate pointers within high bandwidth time periods of the content signal to improve overall control information read/seek times.

**348 Claims, 30 Drawing Sheets**



EXAMPLE STEGANOGRAPHICALLY  
ENCODING ELECTRONIC CONTENTS IN AN IMAGE



US006381747B1

(12) **United States Patent**  
**Wonfor et al.**(10) **Patent No.:** **US 6,381,747 B1**  
(45) **Date of Patent:** **Apr. 30, 2002**(54) **METHOD FOR CONTROLLING COPY PROTECTION IN DIGITAL VIDEO NETWORKS**(75) Inventors: **Peter J. Wonfor**, El Granada; **Derek T. Nelson**, Menlo Park, both of CA (US)(73) Assignee: **Macrovision Corp.**, Sunnyvale, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/142,039**(22) PCT Filed: **Mar. 31, 1997**(86) PCT No.: **PCT/US97/05257**§ 371 Date: **Aug. 31, 1998**§ 102(e) Date: **Aug. 31, 1998**(87) PCT Pub. No.: **WO97/37492**PCT Pub. Date: **Oct. 9, 1997****Related U.S. Application Data**

(60) Provisional application No. 60/014,684, filed on Apr. 1, 1996.

(51) **Int. Cl.<sup>7</sup>** ..... **H04N 7/173**(52) **U.S. Cl.** ..... **725/104**; 386/94; 380/201; 380/203(58) **Field of Search** ..... 348/3, 5.5, 7, 10, 348/12; 386/1, 94; 360/60; 380/201, 203, 204; 725/104, 8, 30, 146, 1, 2, 31, 25(56) **References Cited****U.S. PATENT DOCUMENTS**

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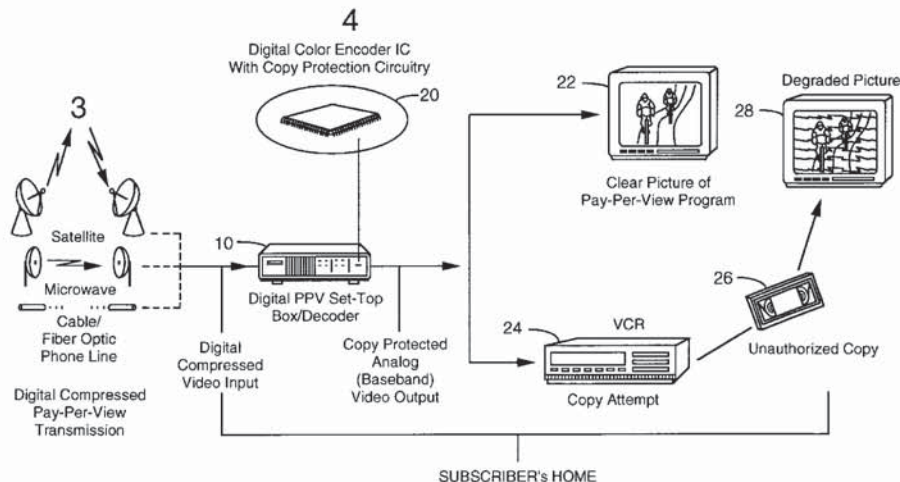
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*Primary Examiner*—Andrew Faile*Assistant Examiner*—Ngoc Vu(74) *Attorney, Agent, or Firm*—George Almeida; Frank Nguyen(57) **ABSTRACT**

A method and system of providing copy protection of video analog and digital signals and the like, wherein the signals are transmitted via a digital delivery network, and may comprise, for example, pay per view (PPV) program materials protected by copyrights of respective program rights holders. The right holders authorize video service providers (3) to apply copy protection to the program material. The copy protection process is supplied to the rights holders or the service providers (3) by a copy protection process licensor. The video service providers (3) supply suitable copy protection control software via respective control and billing (tracking) centers to generate commands which activate, control and reconfigure the copy protection process being applied to the programs being transmitted. A settop box (10) is provided to each consumer and contains a copy protection circuit which is adapted to apply selected anti-copy waveforms to the video signal corresponding to the program material in response to the commands from the service providers (3). Usage data pertinent to each consumer is returned by the settop box (10) to the service providers (3), which then report the copy protection usage to the respective rights holders and process licensor.

**52 Claims, 3 Drawing Sheets**

US006049838A

**United States Patent** [19]**Miller et al.**[11] **Patent Number:** **6,049,838**[45] **Date of Patent:** **Apr. 11, 2000**[54] **PERSISTENT DISTRIBUTED CAPABILITIES**

[75] Inventors: **Mark S. Miller**, Los Altos; **Norman Hardy**, Portola Valley; **E. Dean Tribble**, Los Altos Hills; **Christopher T. Hibbert**, Mountain View; **Eric C. Hill**, Palo Alto, all of Calif.

[73] Assignee: **Sun Microsystems, Inc.**, Mountain View, Calif.

[21] Appl. No.: **08/673,058**[22] Filed: **Jul. 1, 1996**[51] **Int. Cl.**<sup>7</sup> ..... **G06F 15/163**; G06F 9/00; G06F 9/46[52] **U.S. Cl.** ..... **709/303**; 380/49[58] **Field of Search** ..... 395/680, 682, 395/683; 709/300, 302, 303, 229; 380/23, 24, 25, 49[56] **References Cited****U.S. PATENT DOCUMENTS**

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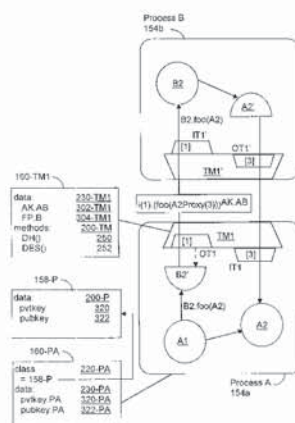
*Primary Examiner*—Alvin E. Oberley

*Assistant Examiner*—Peter Stecher

*Attorney, Agent, or Firm*—Pennie & Edmonds LLP

[57] **ABSTRACT**

A system and method is disclosed that provides persistent capabilities for distributed, object-oriented applications running on generally available hardware. The disclosed system and method operate in a transparent distributed object system where inter-process messaging between the program objects is effected by paired transport managers, proxies and matched in-table and out-table slots. Each object needing to communicate with an object in another address space does so by transparently issuing messages to that object's local proxy. Each process provides a registrar that includes a secret code table wherein an object is registered with a unique, practically unguessable secret code. Anticipating the need to re-establish object-proxy links following a inter-process communications fault, proxies are made revivable, meaning that their links with corresponding remote objects can be revived following a communications interruption. This is accomplished by a makeRevivable method that stores a revivable proxy's expiration date (the date beyond which the proxy is not revivable) and its corresponding remote object's secret code into the proxy's out-table slot. Upon the occurrence of a communications fault, all transport managers and tables are nulled out and then, when the communications fault is corrected, rebuilt by the transport managers. Sometime after the restoration of communications, a revived method is invoked that restores the links between, registered objects and proxies. The objects and proxies are brought back in a consistent state based on limited checkpointed data stored by the distributed program for the registered objects.

**18 Claims, 12 Drawing Sheets**



# United States Patent [19]

Hellman et al.

[11]

4,424,414

[45]

Jan. 3, 1984

[54] EXPONENTIATION CRYPTOGRAPHIC APPARATUS AND METHOD

[75] Inventors: Martin E. Hellman, Stanford, Calif.;  
Stephen C. Pohlig, Acton, Mass.

[73] Assignee: Board of Trustees of the Leland  
Stanford Junior University, Stanford,  
Calif.

[21] Appl. No.: 901,770

[22] Filed: May 1, 1978

[51] Int. Cl.<sup>3</sup> ..... H04K 9/00

[52] U.S. Cl. .... 178/22.11; 178/22.1;  
178/22.14

[58] Field of Search ..... 178/22, 22.1, 22.11,  
178/22.14; 179/1.5 R

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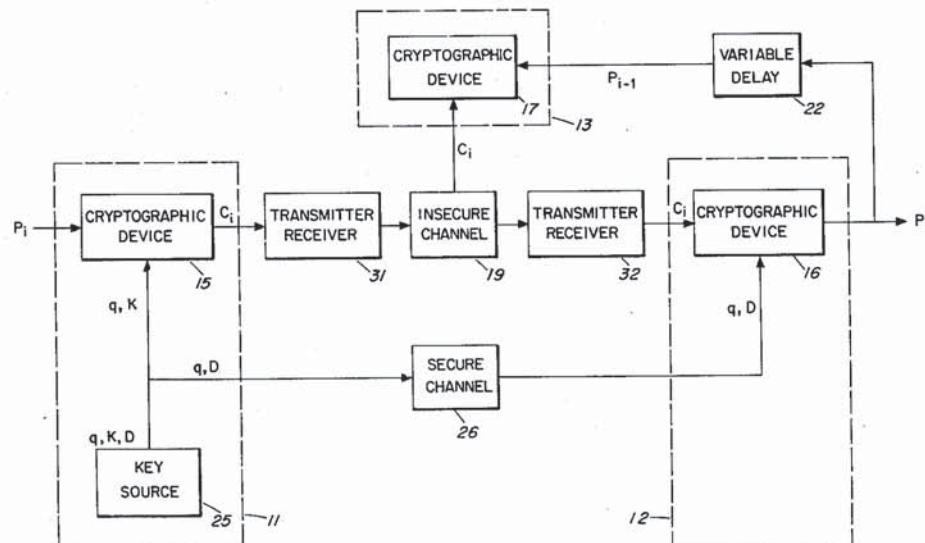
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Jun. 1976.

Primary Examiner—Sal Cangialosi  
Attorney, Agent, or Firm—Flehr, Hohbach, Test,  
Albritton & Herbert

## [57] ABSTRACT

A cryptographic system transmits a computationally secure cryptogram that is generated from a secret transformation of the message sent by the authorized transmitter; the cryptogram is again transformed by the authorized receiver using a secret reciprocal transformation to reproduce the message sent. The secret transformations use secret cipher keys that are known only by the authorized transmitter and receiver. The transformations are performed with nonsecret operations, exponentiation, that are easily performed but extremely difficult to invert. It is computationally infeasible for an eavesdropper either to solve known plaintext-ciphertext pairs for the secret cipher keys, or to invert the nonsecret operations that are used to generate the cryptogram.

2 Claims, 6 Drawing Figures





# United States Patent [19]

Hellman et al.

[11] 4,200,770

[45] Apr. 29, 1980

## [54] CRYPTOGRAPHIC APPARATUS AND METHOD

[75] Inventors: Martin E. Hellman, Stanford; Bailey W. Diffie, Berkeley; Ralph C. Merkle, Palo Alto, all of Calif.

[73] Assignee: Stanford University, Palo Alto, Calif.

[21] Appl. No.: 830,754

[22] Filed: Sep. 6, 1977

[51] Int. Cl.<sup>2</sup> ..... H04L 9/04

[52] U.S. Cl. .... 178/22; 340/149 R; 375/2; 455/26

[58] Field of Search ..... 178/22; 340/149 R

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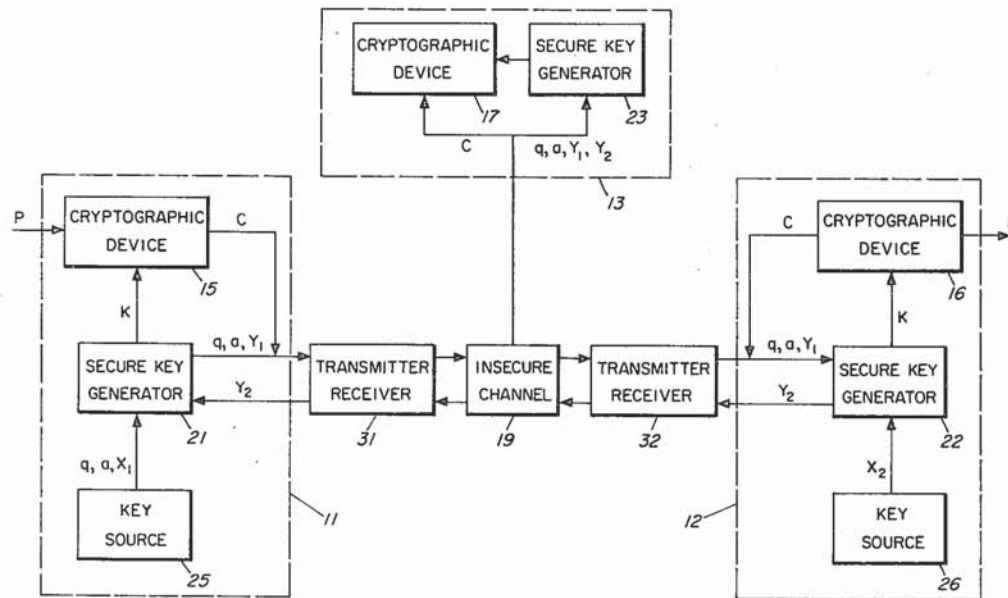
Primary Examiner—Howard A. Birmiel  
Attorney, Agent, or Firm—Flehr, Hohbach, Test

[57]

## ABSTRACT

A cryptographic system transmits a computationally secure cryptogram over an insecure communication channel without prearrangement of a cipher key. A secure cipher key is generated by the conversers from transformations of exchanged transformed signals. The conversers each possess a secret signal and exchange an initial transformation of the secret signal with the other converser. The received transformation of the other converser's secret signal is again transformed with the receiving converser's secret signal to generate a secure cipher key. The transformations use non-secret operations that are easily performed but extremely difficult to invert. It is infeasible for an eavesdropper to invert the initial transformation to obtain either conversers' secret signal, or duplicate the latter transformation to obtain the secure cipher key.

8 Claims, 6 Drawing Figures



# United States Patent [19]

Hellman et al.

[11] 4,218,582

[45] Aug. 19, 1980

## [54] PUBLIC KEY CRYPTOGRAPHIC APPARATUS AND METHOD

[75] Inventors: Martin E. Hellman, Stanford; Ralph C. Merkle, Palo Alto, both of Calif.

[73] Assignee: The Board of Trustees of the Leland Stanford Junior University, Stanford, Calif.

[21] Appl. No.: 839,939

[22] Filed: Oct. 6, 1977

[51] Int. Cl.<sup>2</sup> ..... H04L 9/04

[52] U.S. Cl. .... 178/22; 364/900

[58] Field of Search ..... 178/22

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Primary Examiner—Howard A. Birmiel

## [57] ABSTRACT

A cryptographic system transmits a computationally secure cryptogram that is generated from a publicly known transformation of the message sent by the transmitter; the cryptogram is again transformed by the authorized receiver using a secret reciprocal transformation to reproduce the message sent. The authorized receiver's transformation is known only by the authorized receiver and is used to generate the transmitter's transformation that is made publicly known. The publicly known transformation uses operations that are easily performed but extremely difficult to invert. It is infeasible for an unauthorized receiver to invert the publicly known transformation or duplicate the authorized receiver's secret transformation to obtain the message sent.

17 Claims, 13 Drawing Figures

